

Claims

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1. A photonic device comprising:  
 a first section including a material adapted to interact  
 with photons,

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a second section including a material adapted to  
 interact with photons,  
 with an area of said first section and an area of said  
 second section abutting each other  
 characterized in that

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at least a part of said first area and a part of said  
 second area define a low temperature bonding area.

2. A photonic device according to claim 1, wherein said low  
 temperature bonding area connects said first area and said  
 second area mechanically and optically.

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3. A photonic device according to claim 2, wherein said low  
 temperature bonding area comprises a surface area of said  
 first section and a surface area of said second section which  
 are connected by means of a low temperature bonding method.

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4. A photonic device according to claim 1, wherein said  
 interaction with photons comprises one ore more interaction  
 types of the group of interactions consisting of transmission  
 of photons, reflection of photons, absorption of photons,  
 generation of photons, emission of photons, wavelength  
 conversion of photons, guiding of photons, diffraction of  
 photons, refraction of photons, superimposing photons,  
 generation of photon interference and linear, elliptic and

circular polarization of photons.

5     5.     A photonic device according to claim 1, wherein said second section is a surface area between a first section and a third section.

10     6.     A photonic device according to claim 1 wherein said first section comprises a block of glass with a waveguide and said second section comprises an optical fiber.

15     7.     A photonic device according to claim 1, wherein said first material has at least a portion where an index of refraction is different from an index of refraction of at least a portion of said second material.

20     8.     A photonic device according to claim 7, wherein said photonic device is a wave guide defined in a surface area of said first material and said waveguide is covered by said second material.

25     9.     A photonic device according to claim 8, wherein an essentially two-dimensional optical chip is defined with waveguides connecting active and passive optical components.

30     10.    A photonic device according to claim 7, wherein said waveguide is defined in a bulk area of the first material.

35     11.    A photonic device according to claim 10, wherein said waveguide extends oblique to a surface of said first material.

40     12.    A photonic device according to claim 10, wherein said waveguide in said first material is connected to a waveguide

extending in said second material.

13. A photonic device according to claim 10 wherein, an  
essentially three-dimensional optical chip is defined with  
5 waveguides connecting active and passive optical components.

14. A photonic device according to claim 13, wherein said  
first section comprises a waveguide extending in a bulk  
material and said second section comprises an optical fiber.  
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15. A photonic device according to claim 1, wherein said  
photonic device is a transmitter and said first section  
comprises a light source and said second section comprises a  
splitter for splitting a propagation path of photons emitted  
15 by the light source into a plurality of propagation paths.

16. A photonic device according to claim 15, wherein said  
splitter comprises a material adapted to amplify light from  
said light source.  
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17. A photonic device according to claim 16, wherein said  
material is an active phosphate laser glass.

18. A photonic device according to claim 15, wherein a  
25 distributed Bragg reflector is connected at least to one  
branch of the splitter.

19. A photonic device according to claim 15, wherein a  
modulator is connected to at least one branch of the splitter  
30 for modulating one element of the group consisting of a phase  
of photons, an intensity of photons and a polarization of  
photons, said photons being propagating through said  
modulator.

20. A photonic device according to claim 19, wherein a combiner is connected to the modulator for combining propagation paths of photons and providing a combined  
5 propagation path for the A photons.

21. A photonic device according to claim 20, wherein an optical amplifier is connected to the combiner for amplifying light which propagated through the combiner.

22. A photonic device according to claim 1, wherein said photonic device is a transmitter and said first section comprises a light source, said light source being an element of the group consisting of light emitting diodes, laser  
15 diodes, diode arrays, laser diode arrays, vertical cavity surface emitting lasers (VCSELs), arrays of vertical cavity surface emitting lasers (VCSELs) and glass based laser sources, and

said second section comprises an element of the group consisting of wave guides, optical fibers, beam splitters, Bragg reflectors, distributed Bragg reflectors, tunable Bragg reflectors, light modulators and wavelength dependent absorbers.

23. A photonic device according to claim 1, wherein said photonic device is an amplifier and said first section comprises a wavelength dependent splitter splitting different wavelength bands into different propagation paths and said second section comprises an amplifying material at least for  
25 one of the wavelength bands associated with one of the propagation paths of the wavelength dependent splitter.

24. A photonic device according to claim 23, wherein said wavelength dependent splitter splits light into a plurality of different wavelength bands each of the different wavelength bands associated with a different propagation path and said second section comprises a plurality of portions comprising an amplifying material associated with at least one of the wavelength bands associated.

25. A photonic device according to claim 24, wherein each of the portions comprising amplifying material contains a dopant being a rare earth element adapted in its amplifying characteristics to said associated wavelength band for amplifying light of the said associated wavelength band.

26. A photonic device according to claim 25, wherein each of the portions comprising amplifying material is optically pumped by a diode laser light source adapted to an absorption characteristic of said portion comprising amplifying material.

27. A photonic device according to claim 26, wherein said splitter is an arrayed waveguide grating and splits light into transmission bands essentially centered at 1,3  $\mu\text{m}$ , 1,4  $\mu\text{m}$  and 1,5  $\mu\text{m}$ , said 1,3  $\mu\text{m}$  transmission band being associated with a Praseodym doped Chalcogenide glass and said associated diode laser light source having a pump light wavelengths centered at about 1020 nm, said 1,4  $\mu\text{m}$  transmission band being associated with a Tm doped Fluoride glass and said associated diode laser light source having a pump light wavelengths centered at about 800 nm and said 1,5  $\mu\text{m}$  transmission band being associated with an Erbium doped Phosphate glass and said associated diode laser light source having a pump light wavelengths centered at about 980 nm.

28. A photonic device according to claim 23, wherein a combiner combines propagation paths extending through said plurality of portions comprising amplifying material and is  
5 connected to a waveguide for transmitting amplified light.

29. A photonic device according to one of claim 1, wherein said photonic device is an amplifier having a plurality of amplification portions comprising amplifying material and  
10 arranged serially in a direction of the propagation of light and wherein said first section comprises a first amplification portion and said second section comprises a second amplification portion.

30. A photonic device according to claim 29, wherein each of the amplifying materials is containing a dopant being a rare earth element adapted in its amplifying characteristics to an associated wavelength band for amplifying light of said  
15 associated wavelength band.

31. A photonic device according to claim 30, wherein each of the portions comprising amplifying material is optically pumped by a diode laser light source adapted to an absorption characteristic of said amplifying material.  
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32. A photonic device according to claim 29, wherein said plurality of amplification portions define and overall gain which has an increased gain over an extended wavelength interval in comparison to one of the said amplification  
25 portions.  
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33. A photonic device according to claim 1, wherein said photonic device is a receiver and said first section

comprises a photo detector and said second section comprises at least a waveguide for guiding photons to the photo detector.

5 34. A photonic device according to claim 33, wherein said photo detector is a photo diode.

35. A photonic device according to claim 33, wherein said  
10 second section comprises an light amplifying material for amplification of photons propagating in said waveguide.

36. A photonic device according to claim 35, wherein said  
15 amplifying material comprises a rare earth dopant which is optically pumped by a light source.

37. A photonic device according to claim 36, wherein said  
optical pump light source is a laser diode pump laser.

38. A photonic device according to claim 37, wherein a  
20 waveguide section is connected with said amplifying material and wherein a photo diode is connected to a waveguide of said waveguide section for controlling a pump light intensity of a laser diode pump light source associated with said amplifying material.

25 39. A photonic device according to claim 1, wherein said photonic device is an optical add drop multiplexer and

30 said first section comprises a demultiplexer for demultiplexing light into a plurality of propagation paths and

said second section comprises optical switching means for switching between light from the multiplexer and added

light,

said second section is connected to a multiplexer section for multiplexing light from a plurality of propagation paths to a single propagation path.

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40. A photonic device according to claim 39, wherein said photonic device is an optical add drop multiplexer and said second section comprises a plurality of entrance ports for light to be added and a plurality of exit ports for light to be dropped, said light to be dropped being switched by said optical switching means to the exit ports.

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41. A photonic device according to claim 39, wherein said switching means comprise Mach Zehnder type interferometers for essentially absorption free switching of the propagation direction of photons based on an alteration of the optical path length in at least one of the arms of the Mach Zehnder interferometer.

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42. A photonic device according to claim 41, wherein said alteration of the optical path length of said at least one arm of the Mach Zehnder interferometer is introduced thermooptically.

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43. A photonic device according to claim 41, wherein said alteration of the optical path length of said at least one arm of the Mach Zehnder interferometer is introduced electrooptically.

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44. A photonic device according to claim 41, wherein said dropped light is amplified by an optical amplifier and said demultiplexed light is amplified by an optical amplifier.

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45. A photonic device according to claim 1, wherein said photonic device has at least a first waveguide in said first section comprising a material having an index of refraction  $n_1$  with a positive temperature coefficient  $\partial n_1 / \partial T$  and with at least second waveguide in said second section comprising a material having an index of refraction  $n_2$  with a negative temperature coefficient  $\partial n_2 / \partial T$  said first and said second waveguides being optically connected to each other.

46. A photonic device according to claim 45, wherein an overall temperature coefficient of an effective index of refraction encountered by a photon propagating through the first and second waveguide is essentially temperature independent.

47. A photonic device according to claim 45, having a third section comprising a material having an index of refraction  $n_3$  with a positive temperature coefficient  $\partial n / \partial T$  with a third waveguide in said third section optically connected to said second waveguide.

48. A photonic device according to claim 47, wherein an overall temperature coefficient of an effective index of refraction encountered by a photon propagating through the first, second and third waveguide is essentially temperature independent.

49. A photonic device according to claim 45, wherein said photonic device is a mutliplexer/demultiplexer comprising a plurality of first waveguides, a plurality of second waveguides and a plurality of third waveguides.

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List of Numerals

	1	first embodiment of photonic device
	2	optical substrate defining first section
5	3	upper surface of optical substrate 2
	4	waveguide
	5	second section
	6	lower surface of second section 5
	7	three-dimensional waveguide structure
10	8	optical fibre
	9	cube
	10	cube
	11	cube
	12	cube
15	13	cube
	14	cube
	15	waveguide
	16	waveguide
	17	front surface
20	18	front surface
	19	branch of waveguide splitter
	20	branch of waveguide splitter
	21	branch of waveguide splitter
	22	branch of waveguide splitter
25	23	bend in waveguide
	24	bend in waveguide
	25	connection to waveguide
	26	connection to waveguide
	27	waveguide
30	28	waveguide
	29	optical fiber
	30	optical fiber
	31	waveguide
	32	waveguide
35	33	optical fiber
	34	first section of fourth embodiment
	35	light source
	36	second section of fourth embodiment
	37	splitter
40	38	propagation path
	39	propagation path
	40	propagation path
	41	propagation path
	42	low temperature bonding area
45	43	Bragg grating
	44	modulator
	45	electrode pair
	46	electrode pair
	47	electrode pair

	48	combiner
	49	combined propagation path
	50	optical amplifier
	51	doped glass substrate
5	52	pump laser light source
	53	optical fiber
	54	low temperature bonding area
	55	optical fiber
	56	propagation path
10	57	propagation path
	58	propagation path
	59	wavelength dependent splitter
	60	optical amplifier
	61	optical amplifier
15	62	optical amplifier
	63	low temperature bonding area
	64	combiner
	65	combined propagation path
	66	optical fiber
20	67	silicate glass body
	68	light source
	69	light source
	70	light source
	71	optical amplifier
25	72	optical amplifier
	73	low temperature bonding area
	74	optical fiber
	75	low temperature bonding area
	76	optical propagation path
30	77	pump light source
	78	pump light source
	79	photo detector
	80	photo detector
	81	low temperature bonding area
35	82	optical fiber
	83	photo diode
	84	photo diode
	85	photo diode
	86	optical amplifier
40	87	optical amplifier
	88	optical amplifier
	89	optical fiber
	90	arrayed waveguide grating
	91	low temperature bonding area
45	92	optical propagation path
	93	optical propagation path
	94	optical propagation path
	95	photo diode
	96	photo diode

